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Maritime Geo-Fence Letter Report

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N O T I C E

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1   INTRODUCTION

The United States Coast Guard (USCG) Research and Development Center (RDC) in partnership with the Marine Exchange of Alaska (MXAK) have been exploring the feasibility of various means of transmitting electronic Maritime Safety Information (eMSI) to mariners in the Alaskan area. The communications path evaluated is the Very High Frequency (VHF)-based Automatic Identification System (AIS). For the Arctic Technology Evaluation 2015 (ATE-15), the RDC utilized the CG Cutter HEALY (polar ice breaker) to conduct testing of various AIS Transmit features to determine their utility for improving CG marine safety and security capabilities in the Arctic. During ATE-15 three different operations were tested using AIS Technology.

1) Shore-to-Ship. The MXAK network of shore transmitters (three of which covered parts of the HEALYs route) was used to push out environmental messages (weather data), geographic notices (the ice edges near Barrow) and virtual AtoN messages (synthetic AtoN messages for some of the aids on the light list). Equipment was installed on the HEALY to receive and log this data for later analysis of the coverage range for the transmitter sites.

2) Mobile Base Station (i.e., digital light ship). The HEALY was used as a mobile AIS base station to test the feasibility of this concept for waterways reconstitution after a major storm. Equipment was installed and configured on the HEALY to transmit virtual AtoN messages (synthetic AtoN messages for 139 aids on the light list), and geographic notices (a traffic route overlay and information from the Local Notice to Mariners (LNM)). This information was received by the MXAK network of shore stations and logged for later analysis of the transmit range from the HEALY and message success rate.

3) Moving Security Zone. The equipment on HEALY was also configured to transmit a geographic notice of a security zone centered on the HEALY. The position of this security zone was updated to the current HEALY position at each transmission. This information was received by the MXAK network of shore stations and logged for later analysis of the transmit range from the HEALY and message success rate.

The concept called geo-fencing falls within the third operation above; "moving security zone." The main focus of this document is to discuss the various aspects of geo-fencing.

2   GEO-FENCING

The idea of geo-fencing has been around for some time. The general concept is to have a geographic area or line on an Electronic Chart Systems (ECS), that is used as a "fence" and when a ship crosses the "fence" it triggers some alert or alarm. There are several enabling technologies. First is the ECS, which provides a means to track ships, whether used aboard a ship, or ashore at a Vessel Traffic Service (VTS). Second is the Global Positioning System (GPS), which is the key technology providing the ship's position. Third is the AIS, which provides the means to transmit the ships' positions to each other and to shore. AIS Transmit provides a means to communicate other bits of information from ship-to-ship, ship-to-shore and shore-to-ship.

Geo-fencing can be performed from shore (in this report we will call this: waterways monitoring) and from a ship (ship-based monitoring) and there are several variations that all fall under the broad category of geo-fencing. Each is addressed in the sub-sections below.

2.1 Waterways Monitoring

In this category, the shore authority (VTS, port authority, etc.) creates the geo-fence on their local ECS or Vessel Traffic Service (VTS) system, which receives ship position information via AIS ship reports. If an AIS target crosses the line or enters the area, an alarm is triggered. Figure 1 shows an example of two ships entering a defined area. The orange lines indicate the past positions of the ships and the concentric circles are the visual indication of the alarm condition. Sophisticated systems could use dead reckoning to give advance notice of a possible incursion. The alerts could be local alarms (audible and/or visual) and/or fed to an email or text alert to an operator. This capability is available now in many ECS and VTS systems; many VTSs and port authorities set up geo-fence lines or areas to generate local alerts to the operator.

In a more sophisticated version of this, the alarms could also be used to generate messages to inform the violator via AIS message. This shore-triggered AIS message could be an AIS message 12, addressed safety-related text message or AIS message 6, an addressed binary - Application Specific Message (ASM). The shore authority's ECS would need to be capable of generating the message and also need to be connected to the AIS transmit infrastructure (i.e., Nationwide AIS (NAIS)). Some VTS systems provide the capability to generate AIS message 12 notifications, but there are no systems that can currently generate ASM notifications.
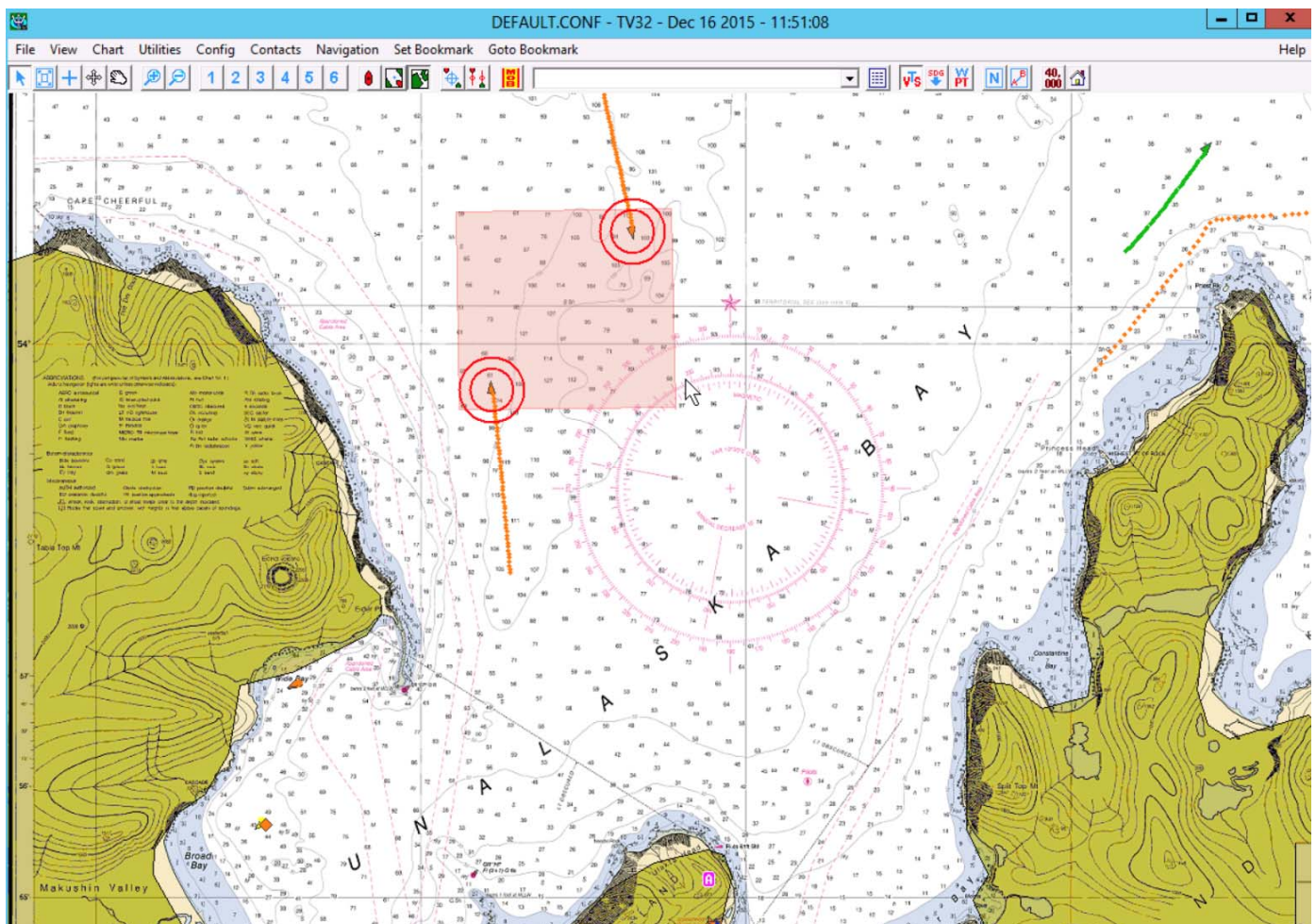

Figure 1. Geo-fence Example: Two vessels entering the defined area trigger alarms.

2.2 Ship-based monitoring

In this case the monitoring is done by the operator on the ship's ECS. The geo-fence line or area could either be entered by the operator or received from a Shore Authority via AIS as an ASM. Once the line or area is accepted and displayed by the ECS, the ship's ECS would monitor the "fence" and trigger the alert of an incursion (or imminent incursion) to the operator. This capability is available now in many ECS systems, though has not been tested by RDC.

A variant of this is for a ship to use a received geo-fence to generate local alerts, aboard the vessel. To do this, the ship's ECS would need to be able to:

a) decode the received ASM area/line overlay from the Shore Authority (i.e., VTS) and;
b) use this overlay as an alert zone similar to locally created areas/lines.

This variant has also not been tested or demonstrated; although creating and transmitting a zone using the Geographic Notice (GN) ASM has been tested.

2.3 Moving Security Zone

A subset of the geo-fence is the "moving security zone." In this variant, an area overlay centered on a ship is transmitted using an AIS ASM. The center position of the area is updated to the current position of the ship each time the ASM is transmitted. The faster the ship is moving, the more often the ASM should be (updated and) transmitted. This type of geo-fence could be transmitted from the ship itself or from a shore transmitter.

The ship-transmitted option was demonstrated by the CGC HEALY during Arctic Shield 2015; an ECS display of this is shown in Figure 2. To enable this, custom software was used on CGC HEALY (see Figure 3 for a block diagram of all of the software used during Arctic Shield).
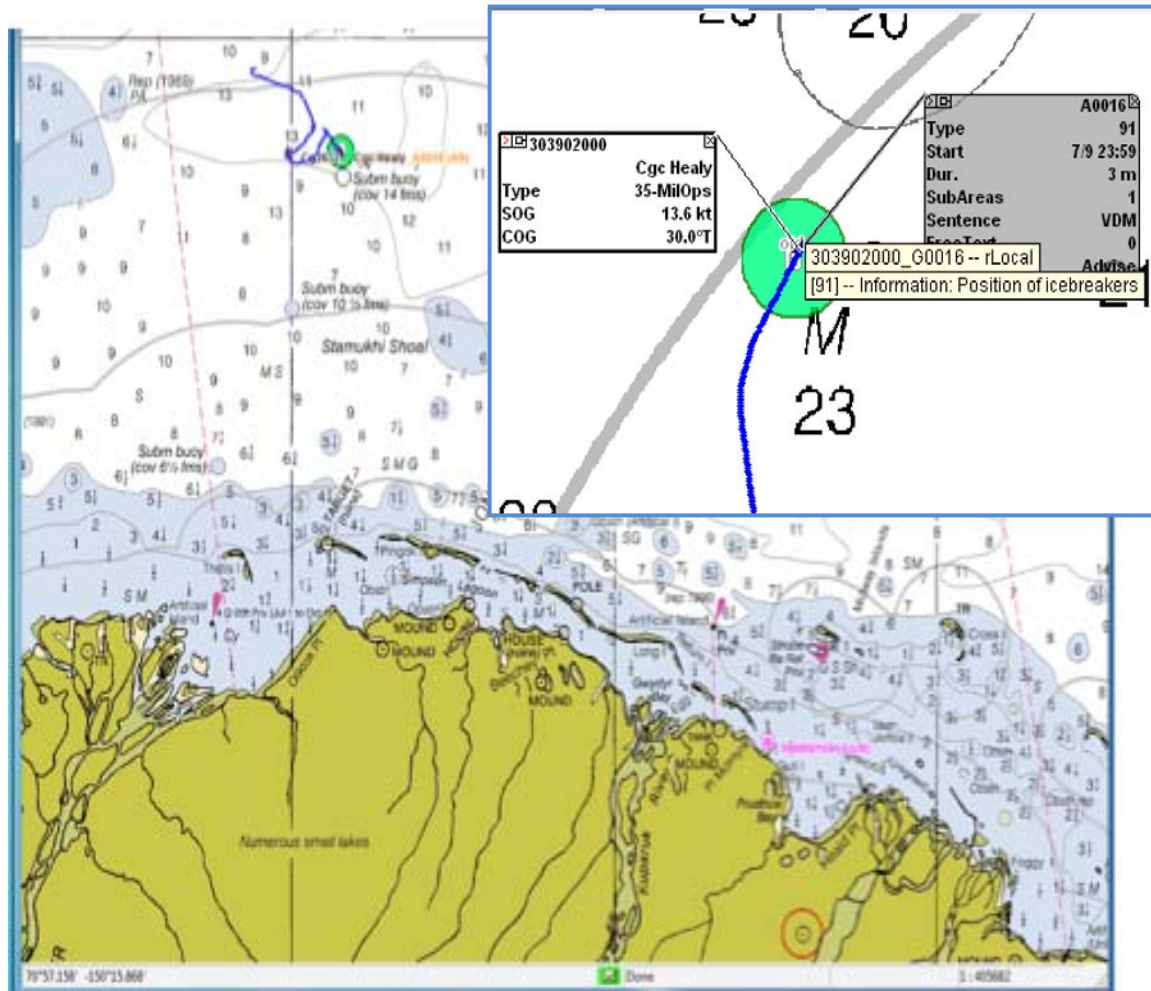
Figure 2. Moving security zone around CGC HEALY during Arctic Shield 2015.

The Moving Security Zone software was used to monitor the ship's position (obtained from the GPS embedded in the AIS equipment); and then at the specified interval, generate the GN ASM that defined the security zone centered at the ship's position. These ASMs were passed off to the Message Passing Interface (MPI) software, which managed the serial connection to the AIS transmitter (and also logged data). The HEALY was also transmitting other message types (synthetic AtoNs), which were managed by the ASM Manager software that provided buffering and repeating capability. This software is shown in Figure 3, but was not part of the moving security zone generation. TV32 software was also installed on the laptop and displayed all of the messages being transmitted so that shipboard personnel could monitor what was going on.
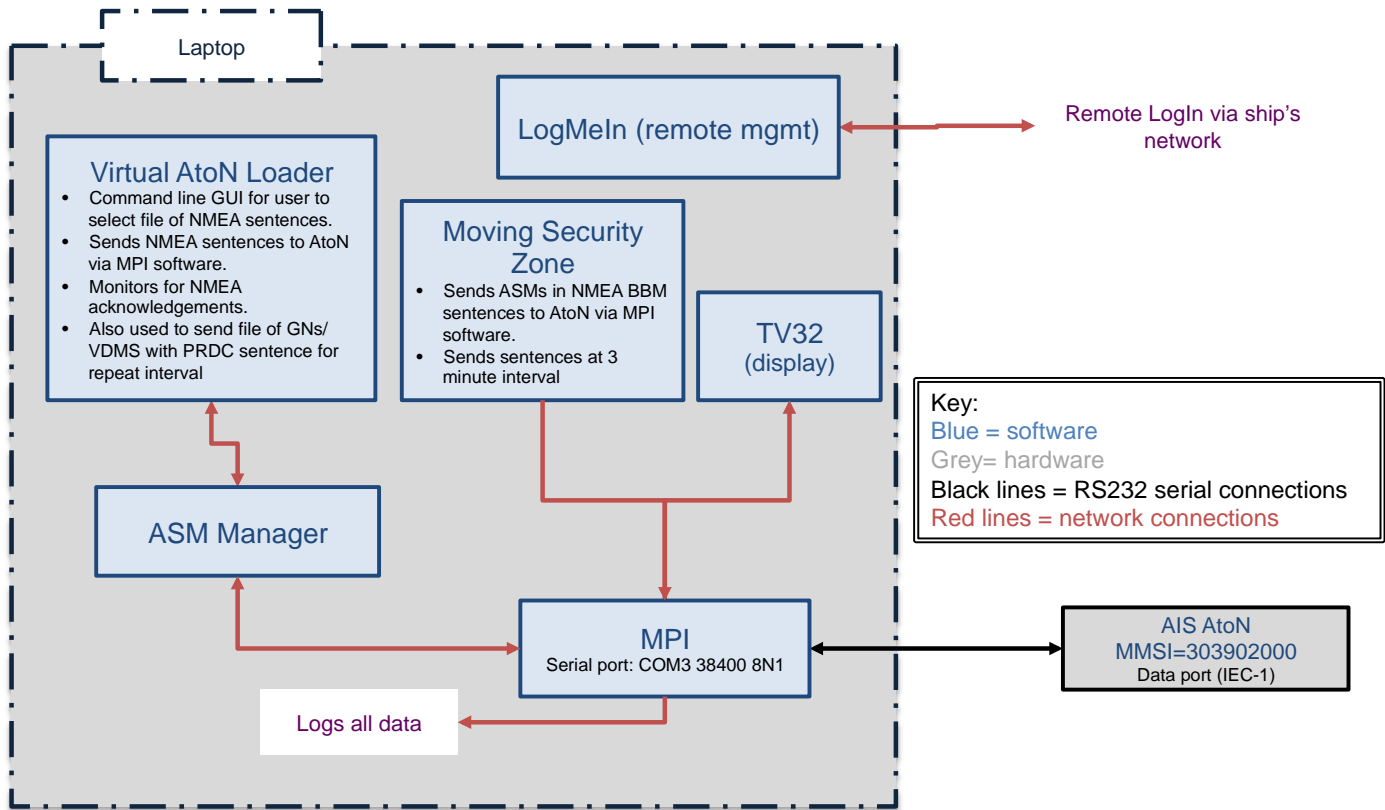
Figure 3. Software architecture on CGC HEALY.

The option of a shore-transmitted "moving security zone" has not been demonstrated. To do this would require the Shore Authority's ECS or system(s) to be able to process the received vessel's AIS position message, create the appropriate GN ASM, and provide the ASM to the AIS transmit system (i.e., NAIS).

When creating a security zone message around a moving vessel it is vital to have the current position of the vessel. This means the shore facility needs real-time monitoring, not vessel positions provided every five minutes; which is sometimes the case when using web-based systems. Another source of lag is when a transmit message (ASM) is in the queue waiting to be sent (for instance when transmit is set for 1 minute intervals). Again, the message will be sent after the vessel has moved and the security zone will lag behind the vessel. One solution is to have message jump to the top of the queue by utilizing priority flag and changing the transmit cycle to several seconds rather than a minute. Ideally, some testing of various combinations should be done to ensure moving security zone lag is minimized when sending from shore.

There are some advantages to this method even though there are implementation complexities. First, the software only needs to be installed at the shore facility, not on every vessel transmitting moving security zones. Second, this allows moving security zones to be set up around non-AIS-equipped vessels. Third, the base station can use reserved slots for the messages making them more likely to be transmitted and received. And finally, the base station may have a larger transmit coverage area than the ship transmitter so that the messages are received farther away from the ship.

3   CONCLUSIONS

The cooperation between the RDC and MXAK is projected to extend into the future to provide the USCG access to the transmit coverage area provided by MXAK AIS transmitters and to conduct research and development into options to provide eMSI over a broader coverage area than that provided by AIS. The transmit capability currently provided by MXAK has been put to good use during Arctic Shield 2015, where a variety of advanced capabilities were demonstrated: virtual AtoNs, digital lightship, eMSI (environmental information and ice edges) and moving security zones. The technology to support geo-fencing exists and can be applied in several ways (i.e., waterways monitoring; vessel-based monitoring; transmit ASM notifications from shore to vessels; AIS-transmitted geo-fence to generate local alerts aboard vessels; moving security zone transmitted from the vessel itself or from a shore transmitter).

Following is a summary of the various geo-fencing options and their current state of implementation and recommendations:

1) Some geo-fencing can be done now with the existing software system; most ship ECS and shore VTS systems support the creation of zones that can be used to trigger alerts. This allows either ship-based or waterways monitoring to be done. While it is currently possible to create and transmit zones for display on a shipboard ECS using the GN ASM, there is currently no provision for these to be turned into alertable zones. **The USCG should work with ECS manufacturers to add this capability into their ECS systems. This feature should also be added into the RTCM SC109 ECS standard.**

2) There are currently some VTS systems that can generate AIS message 12 text messages to ships in response to an alert. In order to send AIS message 6 ASMs to notify ships of incursions some software development needs to be done. Since using an ASM allows for more information to be transmitted more efficiently and allows for better integration with the ECS upon receipt, this alternative should be explored. **The USCG should create an ASM for this application and then develop software to create the messages in response to zone alerts. This could be prototyped and tested by RDC.**

3) Generation of moving security zones is not currently possible. The ship-based method is usually easier, but requires software on the ship to create and transmit the messages. **The USCG should require this for certain ships such as LNG carriers that typically have security zones in effect around them as they traverse a harbor.** This requirement would then be used as justification for ECS manufacturers to add the capability to their shipboard systems. **Alternatively, this could be a requirement for the pilots, who would then have the capability added to their Portable Pilot Unit (PPU) equipment.**

4) The shore-based method of generating moving security zones is advantageous in that it could be used to create a moving security zone around a ship that does not have AIS. This would require the development of custom software on the shore side to implement this. Although the software is more complex, the deployment of this option is easier since the software only needs to be installed on the USCG system, and not on each ship that needs to transmit the moving security zone. **The USCG should develop the software to do this; it could be prototyped and tested by RDC.**